PAV-80-04

# Preventive Pavement Maintenance Concepts

**W.E. Blum**
Engineering and
Right-of-Way Officer
Geotechnical Section
Eastern Region

**W.A. Phang**
Head,Pavement Research Branch
Engineering Research and Development
Research and Development Division

Published by:
The Policy Planning and Research Division
Ontario Ministry of Transportation and Communications
Hon. James W. Snow, Minister
H.F. Gilbert, Deputy Minister

This report may be reproduced, whole or
in part, with attribution to the Ministry

For additional copies write:
The Editor
Research and Development Branch
Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

Printed January 1981

ABSTRACT

Pavement maintenance activities have tended to concentrate on correcting deficiencies which are potentially hazardous or which immediately effect the serviceability of the pavement. Maintenance activities which address defects that have a potential for accelerating degradation in serviceability have been spasmodic and sometimes futile. The concept is advanced, of systematically waterproofing, draining, and locally strengthening pavements to retard the progression of defects and create benefits through extension of useful pavement life.

The types of treatment used to effect preventive maintenance are described, and the timing and reasons for their application are discussed. The benefits achieved through extension of life are quantified and used to calculate benefit/cost ratios.

An example is given of the development of a program of preventive maintenance based on prioritizing through assessment of benefit/cost ratios, through assessment of the risk element, and through assessment of traffic.

The influence of preventive maintenance programs in rehabilitation programs is discussed. It is recommended that preventive maintenance be recognized as an inclusive part of any maintenance or pavement management system, and that a program of 'catch up' and 'on-going' preventive maintenance be implemented forthwith.

## 1/ INTRODUCTION

Preventive maintenance has instinctive appeal to highway jurisdictions beleagured by problems of continuing high inflation, alarming price rises in asphalts and fuels, drop in highway financing (1) and increased maintenance demand resulting from the slowdown in new construction and re-construction of highways. Preventive maintenance, like the proverbial stitch-in- time-saves-nine, reduces the rate of pavement deterioration, thereby making the pavement more serviceable over a longer period of time. Longer useful pavement life postpones the day when renewal will be required, and eases the demand on scarce highway funds. More serviceable pavements keep vehicles operating at low cost levels, thus making a major contribution to savings for the community (2).

Preventive maintenance is not to be confused with maintenance treatments made to correct deficiencies which have already progressed to a stage where they interfere noticeably with the reliability, speed, and safety of vehicle operation. Such activities are usually carried out to keep a pavement within tolerable conditions of serviceability, but they can be done as well to postpone pavement rehabilitation, likely though, at high cost.

Although reference to the successful use of preventive maintenance in Kansas appears in the literature (3), little attempt appears generally to have been made to systematically differentiate between preventive maintenance and corrective maintenance, nor to develop any systematic approach to preventive maintenance. Rather maintenance has tended to be defined either as short term, routine, or day-to-day maintenance, or as long term, periodic, or programmed maintenance (4). A more systematic approach to the total maintenance picture has been developed within the Ontario Ministry of Transportation and Communications. Pavement quality standards for the maintenance management system are being revised to introduce more uniform methods of deficiency identification, and to foster pursuit of courses of corrective action which are estimated to be most cost effective (5). These deficiency-corrective actions are complemented by courses of action which anticipate the occurrence of deficiencies or which are intended to retard progression of defects. These anticipatory actions fit under the term 'preventive maintenance.'

A methodology is described for:
(1) the identification of suitable candidates for preventive maintenance;
(2) the types of maintenance treatments which are used in preventive maintenance,
(3) the quantification of benefits and costs; and
(4) the assessment of risk.

The methodology is utilized to formulate a priority listing of preventive maintenance projects, from which a work program is

then formulated. An initial catch-up program is suggested followed by annual programs, accompanied by careful monitoring for the first few years at least.

An example of a program in one Regional area is presented.

## 2/ DEFINITIONS

It is appropriate at this time to define a few key words used in this report.

### 2.1/ Preventive Maintenance

Maintenance actions taken to prevent premature deterioration and/or retard the progression of deficiencies, so as to slow down the rate of deterioration and effectively increase the useful life.

Examples of preventive maintenance are:
(1) the exclusion of water from the pavement structure by crack routing and sealing, or by sealing adjacent gravel shoulders;
(2) the drainage or interception of water from the pavement structure by pavement edge and other subsurface drains;
(3) the protection of vulnerable elements of the pavement by sealing open and ravelled surfaces; and
(4) the strengthening of sections of pavement which are below average strength due to poor local soil conditions.

### 2.2/ Corrective Maintenance

Maintenance actions taken to correct deficiencies which are potentially hazardous and to repair defects which seriously affect serviceability, so as to maintain or keep the pavement within a tolerable level of serviceability.

Examples of corrective maintenance are:
(1) temporary ramps to dangerously excessive differential frost heave bumps, or permanent insulation treatment of these heaves.
(2) filling potholes to retain safe driving conditions.
(3) replacing damaged culverts to maintain adequate surface drainage.
(4) regrading shoulders to solve shoulder drop off problems.

### 2.3/ Rehabilitation

Actions taken to restore initial pavement serviceability such as by pavement overlay.

### 2.4/ Reconstruction

Actions taken to both regain high initial serviceability and as well to improve the operational level of service, such as accomplished by widening and new alignment.

The differences in performance expected by each of the above actions of preventive and corrective maintenance, rehabilitation and reconstruction are illustrated in Figure 1.

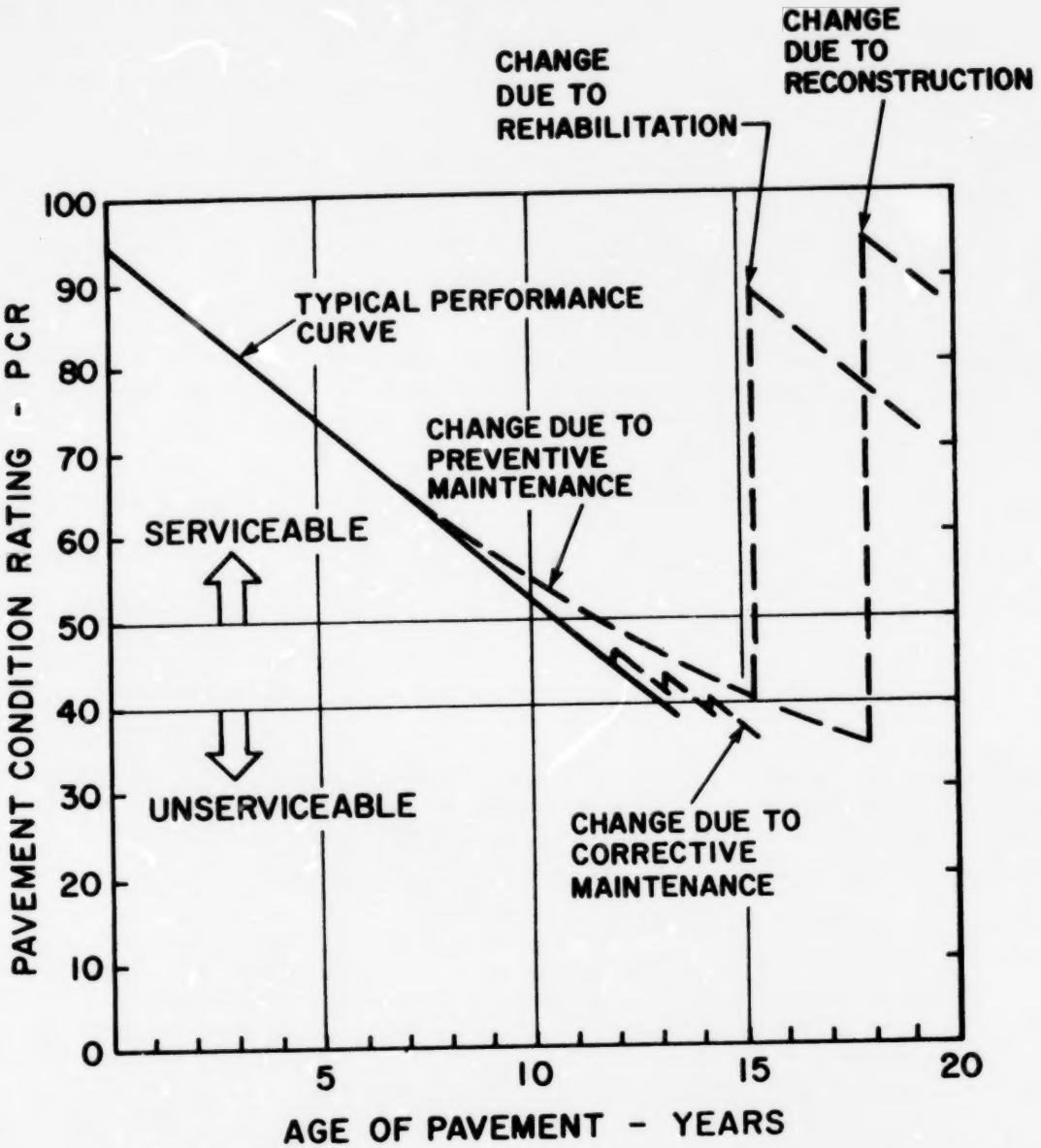



Figure 1/ Typical Anticipated Changes in Performance Due to Maintenance, Rehabilitation and Reconstruction

## 3/ PREVENTIVE MAINTENANCE CONCEPTS

There are essentially only three basic premises for the application of preventive maintenance; 1) prevent ingress of water (waterproof); 2) remove water from the pavement structure and subgrade (drain); and 3) strengthen those sections of pavement which reflect local weaknesses due to poor local soil conditions.

### 3.1/ Waterproofing

Water that enters a pavement structure from above, could enter through cracks and joints, through the pavement edge where there is an unsealed shoulder, or through porous pavement materials. The destructive effects of traffic are markedly increased by the presence of excessive moisture in the pavement structure, and this is well illustrated by Cedergren in Reference 6. Figures 2 and 3 show examples of pavement damage from water entering the surface through cracks and joints. In Figure 2, the single low temperature transverse crack has progressed to multiple cracking, depressed at the crack. In Figure 3, the midslab cracks have faulted and longitudinal edge Figure 4 illustrates pavement edge damage resulting from water entering the pavement structure through the 'exposed' edges, unsealed shoulders, during the late winter/early spring period (7).

### 3.2/ Drainage

Water that enters a pavement structure from below, could enter through the subgrade because of high water table effects, capillary effects, and thermal gradient effects (6). Water entering the shoulder area from above, may be prevented from lateral drainage towards the ditches by clay slopes or blocked ditches; this trapped water likely enters the pavement structure through the sub-base layers (7). Figure 5 illustrates pavement damage caused by water entering the subgrade or sub- base areas probably as a result of high ground water and ice filled ditches.

### 3.3/ Strengthening

Measurements of pavement strength (deflection or rebound response to load) usually show significant strength variations. For example, if the mean rebound measurement of a pavement is $\bar{x}$ = 1.24 mm, the standard deviation $\sigma$, may be as high as 1/3rd of the mean, i.e. about $\sigma$ = 0.4 mm. Thus, while 95% of the rebounds would be below $\bar{x} + 1.6\,\sigma$ = 1.89 mm, 5% of the measurements exceed this value (8), see Figures 6a and 6b. This 5% of pavement could deteriorate at a much faster rate than the rest of the pavement. If the 5% of measurements about 1.89 mm are clustered at specific locations, indicating locally poor soil conditions, strengthening of these sections by hot mix patching should correct this situation, together with whatever appropriate drainage treatment is needed. See Figure 6c.

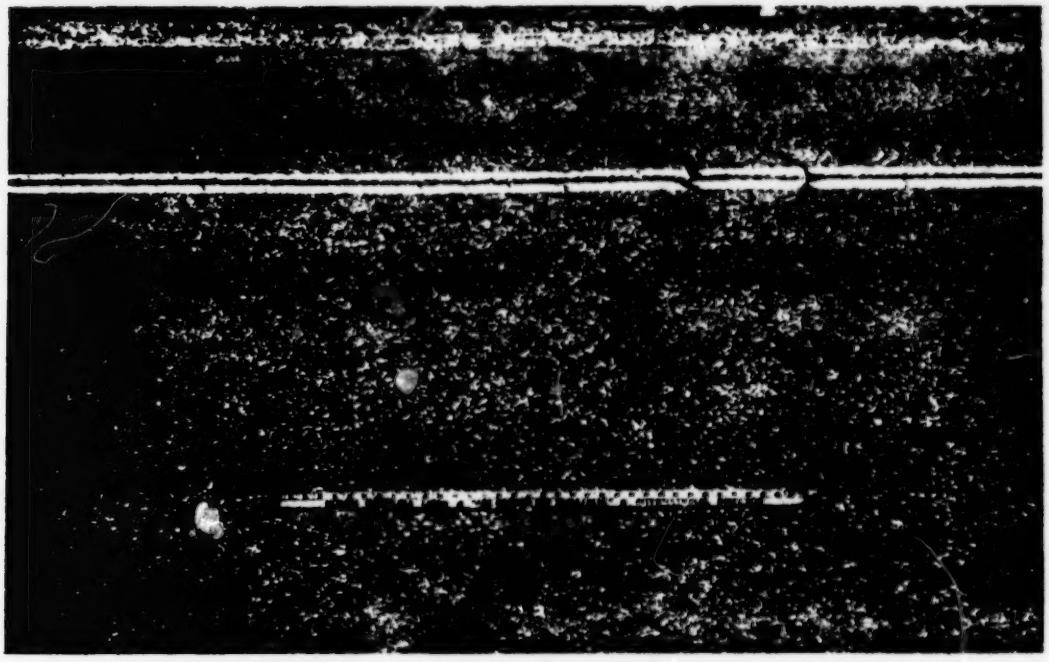
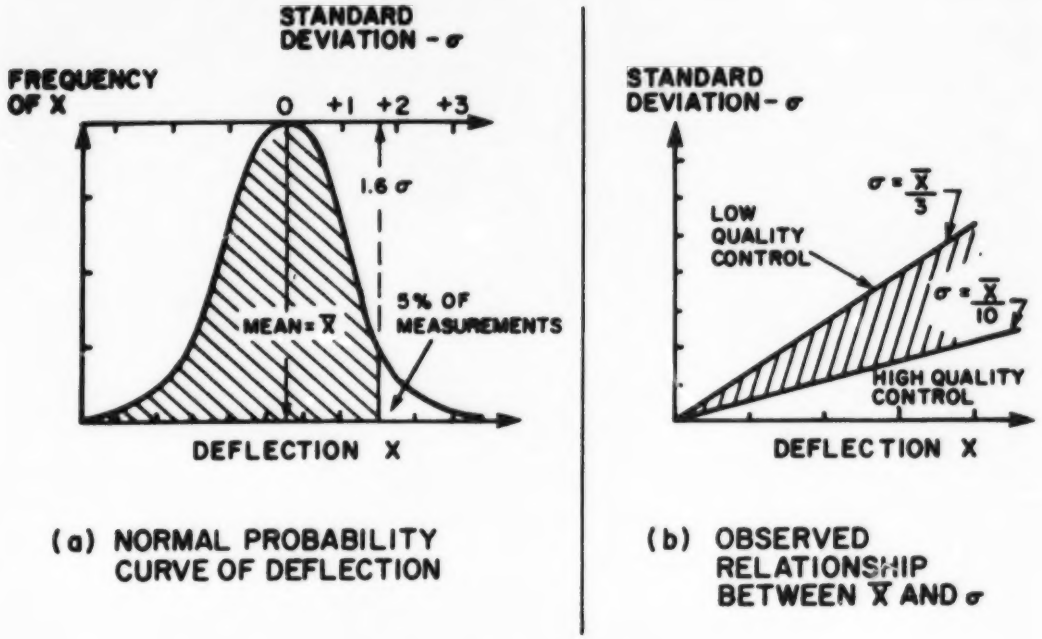


Figure 2/ Single Transverse Crack in an Asphalt Pavement which has Progressed to a Depressed Multiple Transverse Crack

Figure 3/ Faulted Mid-Slab Crack in a Concrete Pavement with Longitudinal Restraint Cracks

Figure 4/ Pavement Edge Cracks which have Progressed to Middle of Lane

Figure 5/ Water Seeping out of Broken Up Area and Cracks in Pavement




AFTER REF 8

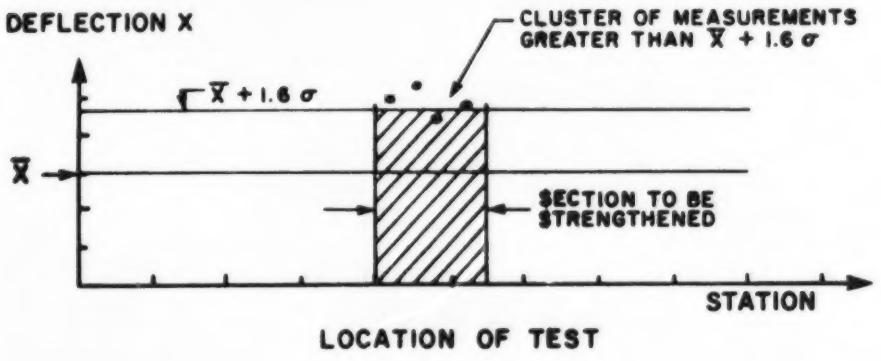

DEFLECTION X
CLUSTER OF MEASUREMENTS GREATER THAN X̄ + 1.6 σ
X̄ + 1.6 σ
X̄
SECTION TO BE STRENGTHENED
STATION
LOCATION OF TEST
(c) IDENTIFICATION OF SECTIONS WITH HIGH PROBABILITY OF FASTER DETERIORATION

Figure 6/ Illustration of Rationale for Local Pavement Strengthening

### 3.4/ Timing

Ideally, preventive mainenance should be carried out as soon as the distress appears. In practice, distresses are not noticed until they progress sufficiently to affect pavement serviceability, but they should be attended to as soon after being noticed as possible. Further, unless there is a sufficient quantity of the particular maintenance treatment needed in the area, the practicality of carrying it out is low. As well, availability of equipment would affect the timing of the repair. Whenever there is a combination of these circumstances, and the distressed condition begins to manifest itself on a wider scale, then special arrangements can be made to carry out the maintenance work by combined patrol forces or by contract forces. However, if the distressed condition is allowed to lapse for too long a period so that the serviceability of the pavement becomes too close to where rehabilitation is envisaged, then it would likely be unrewarding to undertake preventive maintenance activities.

## 4/ CANDIDATES FOR PREVENTIVE MAINTENANCE

All pavements will benefit from the application of preventive maintenance treatments. However, the beneficial effects will differ depending on the characteristics of the pavement structure. It can be said in general, that more structurally sound (stronger) pavements would benefit more than pavements which are weaker. The reasoning behind this statement is illustrated in Figure 7. The benefits in terms of extension in service life for stronger, normal, and weaker pavements, depend upon the changes in rate of deterioration imparted by the application of preventive maintenance. Thus it can be seen from the diagram that a small change in the rate of deterioration of a stronger pavement, which already has a lower rate of deterioration, would have a larger effect on life extension than the same small change in deterioration would have on a weaker pavement, which already has a higher rate of deterioration.

This statement can be translated into terms which can be more fully appreciated by financial analysts, i.e. the risk which one takes in investing preventive maintenance funds in a stronger pavement is low, while there is a high risk in investing preventive maintenance funds in pavements which are weaker. Thus one criteria for recognizing candidates for preventive maintenance may be identified by reference to records of pavement condition ratings (PCR). The shaded area shows medium to low-risk-rating pavements, with timing of non-patrol type preventive maintenance activity occurring between PCR values of 70 and 55. These values are of course, subject to review.

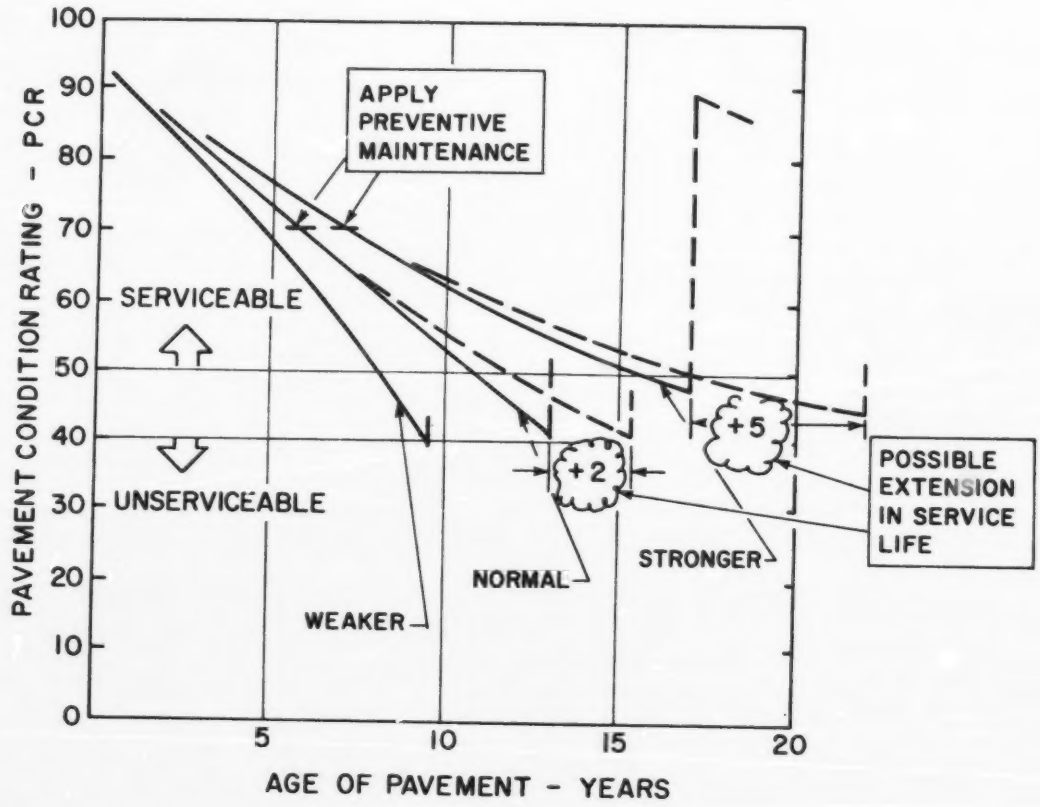



**Figure 7/ Illustration of Benefits in Terms of Extended Pavement Life**

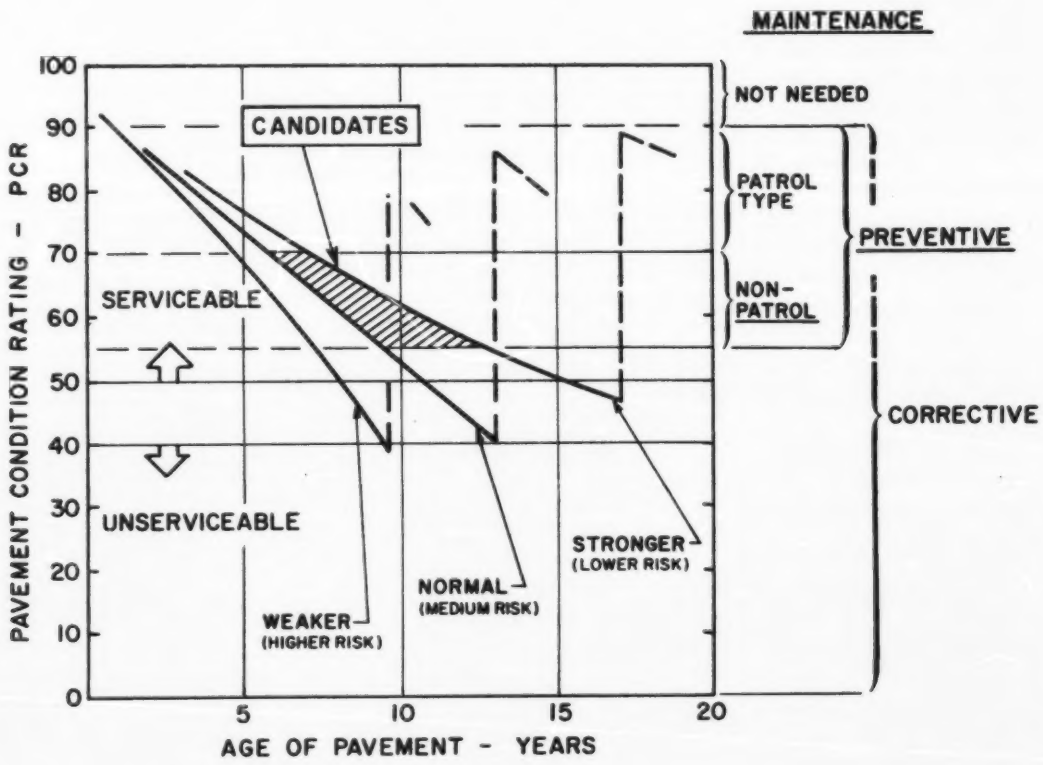



**Figure 8/ Proposed Criteria for Identifying Candidates for Preventative Maintenance**

## 5/ APPLICATION OF PREVENTIVE MAINTENANCE CONCEPTS

Pavement condition rating evaluations and reviews are carried out on a routine and systematic manner on all pavements in the Province of Ontario. This type of rating evaluation and review involves a physical inspection of the pavement structure for the purposes of ascertaining the performance level and of recording all visibly discernable types of distress. Pavement condition rating numbers (PCR's) are assigned to each individual section of road using a 0-100 performance rating scale. This method of pavement condition rating allows for an individual assessment of both performance and deficiencies and provides the information necessary for determining long term pavement performance and needs.

The serviceable period of pavement life normally occurs during the time period when the pavement condition rating number remains within the values 100 and 50. This would be the period during which preventive maintenance work is undertaken. Pavements with pavement condition rating numbers less than 50, would be candidates for rehabilitation through resurfacing, and corrective maintenance would be needed until rehabilitation takes place.

### 5.1/ Deficiency Types and Treatment

Performance deficiency conditions that have directly or indirectly resulted because of excessive moisture are prime candidates for preventive maintenance types of treatment.

#### 5.1.1/ Pavement Cracking

One of the most familiar and common types of pavement distress is 'cracking' of which there are many types resulting from many causes.

In asphalt pavement structures oxidation and 'hardening' of the asphalt cement begins at the asphalt plant during the mixing operation and continues in place in the road. As the asphalt pavement 'ages' it becomes more susceptible to cracking which may be thermally or dynamically load induced.

Transverse cracking is one of the typical cracking patterns that develop in this manner.

It can be clearly illustrated that asphalt pavements under heavy traffic conditions having the types of distress that allow unimpeded entry of surface water into the underlying granular base will exhibit poor pavement performance. The pavement structure may begin to depress on either side of the developed cracks particularly during the spring, and as well in the summer and fall periods when surface water gains free and easy access to the underlying granular base. A loss of material fines occurs sometimes accompanied by a general reduction in subbase support capability. In winter an upward curling of the pavement may develop on both sides of the crack due to the freezing of the wet or

saturated subbase material at the crack location. Unsealed transverse cracks can contribute not only to a progressively 'rough' ride but a general degradation of the pavement structure at the crack locations by the subsequent development of progressive cracking due to repeated pavement 'flexing' and loss of support. (Refer to Figure 2).

Where concrete pavements have been constructed directly over a granular base the development of intermediate slab cracks provides for easy entry of water at these locations. Loss of base materials and a reduction in bearing capacity at these locations may eventually cause the 'slabs' to tilt in the direction of traffic with subsequent stepping occurring which can exceed one inch in vertical depth. This condition when it occurs, has a dramatic affect on the rideability and may proceed to the point where safety of the ride is a concern. (Refer to Figure 3).

In composite pavement structures particularly where cement stabilized bases containing low cement contents form the underlying composite layer, other types of degrading occurrences may result. Cement treated bases because of their low cement content and lack of entrained air, have little resistance to the effects of road salt, water, and freeze-thaw action. With the entry of road salt and water at the cracks, localized degradation of the underlying base may soon begin manifesting itself resulting in cracking and alligatoring of the asphaltic overlay, loss of asphaltic material, extensive localized road bed deformation and a rough riding surface which may necessitate prompt corrective maintenance or more extensive types of rehabilitation. (Refer to Figure 9).

Where portland cement concrete pavement has been used as the base material in composite pavement designs, moisture shrinkage and temperature movement of the slabs usually result in reflection cracking in the asphaltic pavement, and subsequent loss of material due to spalling at the crack locations which once again may require corrective maintenance. Penetration of water in these reflection cracks may result in lipping or tenting of the crack in winter months, creating very poor riding quality.

In Ontario, with the exception of certain urban expressways and freeways, it has not been the usual practice over the years to pave shoulder areas. Partially-paved shoulders were introduced a few years ago on all resurfaced and reconstructed roads where the traffic volumes (AADT) exceeded 4000. Partially-paved shoulders of this type are in most cases a simple extension of the surface course an additional two feet on either side of the delineated pavement. Consequently, the majority of roads within the Provincial system have either untreated granular or partial width treated shoulders.

Much water consequently enters directly into the road base and subbase through these untreated or 'open' shoulder areas.

**Figure 9/ Six Years After Construction the Extensive Degradation of the Underlying Cement Treated Base is Evident**

Progressive 'edge' cracking on asphalt pavements is one example of the induced damage caused by repeated 'curling' of the outer pavement edge during successive winter periods of freezing and uplift which is some cases is great enough to actually 'pond' water across the road surface. (See Figure 10).

In many instances localized frost heaving particularly near the pavement edge may be directly attributable to the ingress of water through the shoulder areas during the Spring thaw period.

Water entry at these locations may be the direct cause of pavement failure during this time period, particularly in the outer wheel path areas. A rapid infusion of water into the road base material via the shoulder areas where good internal drainage is impeded by the frozen or partially frozen subbase, subgrade, and shoulders may reduce the bearing capacity of the road structure to the point where 'breakup' occurs. It is the uncontrolled entry of water through the shoulder area and entrapment in the structure that results in so many 'weakened' or badly performing areas of pavement. (Refer to Figure 11).

5.2/ Pavement Structure Types and Performance

At the design stage different types of pavement structure designs such as conventional granular, deep strength, and full depth asphalt, plain jointed concrete, and composite are expected to behave as similar pavements have previously performed. Traffic volumes and pavement types constitute one of the more important design parameters.

Although some pavements designed for 'high' traffic volumes and loading conditions are designed 'stronger' the degrading effects of heavy traffic may have greater adverse effects than normal on the service life of the pavement structure. These pavements are perhaps more susceptible to water induced or related types of damage.

Pavement type and traffic conditions are considerations in selecting candidates for preventive maintenance where 'least risk' is a determining factor.

5.3/ Treatment Methods, Materials and Procedures

5.3.1/ Crack Sealing

Probably the most reliable method of sealing cracks in asphaltic or concrete pavements is by routing and sealing with one of the many hot poured rubberized asphaltic sealers available on the market today.

The routing operation is essential in that a most suitable length-width opening be made available at the crack location for the joint filler material.

Most failures occur under tension in the winter time because of bond failure between the sealant and the joint or crack face. Adhesion failure during the winter months causes some lessening of the effectiveness of the seal during this period, but the joint filler still serves to keep out most of the surface water. Renewed adhesion sometimes takes place during the hot summer months when the crack openings reduce in size and the joint sealing compound softens and is knitted to the vertically routed faces by traffic action.

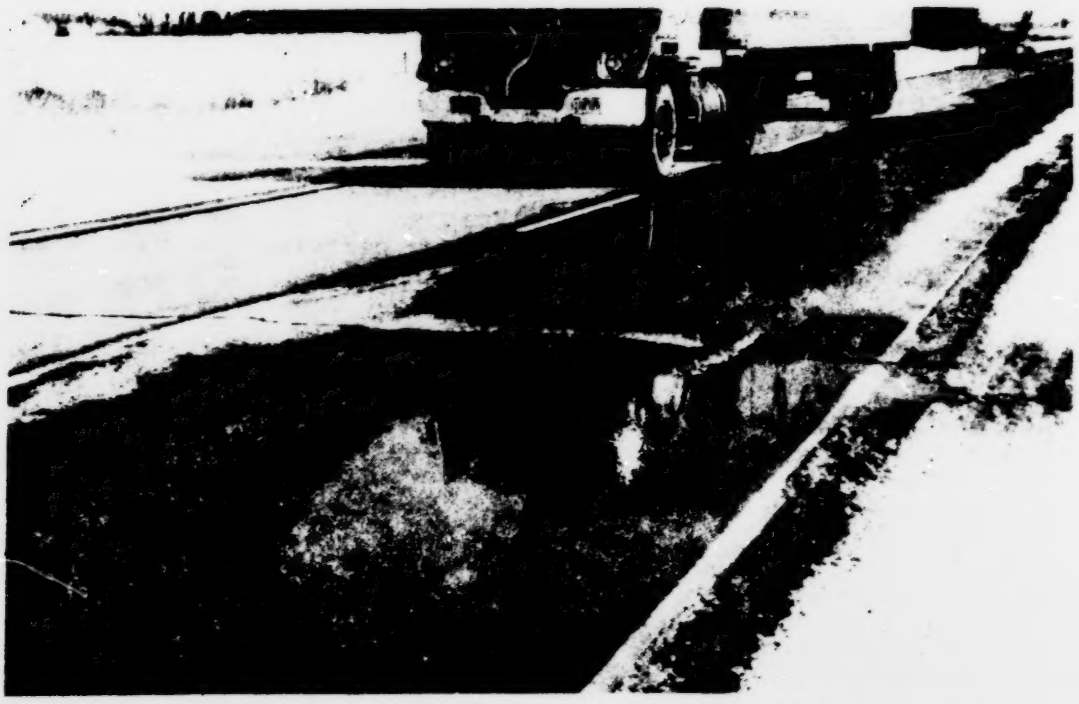


**Figure 10/ Excessive 'Curling' of the Outer Pavement Edge During the Winter has Trapped Water Across the Road Surface**

**Figure 11/ Pavement Breakup Extending for Approximately One Half Mile, Immediately Following a Heavy Spring Rain**

An experimental sealing compound currently in the development stage does not require routing to effect a seal; certainly an important cost consideration in a sealing operation. The excellent adhesion and low temperature flow properties of this type of material are such that it can respond to large movements without a bond break or being abraded away by traffic action or removal by snow plows. A cold applied surface preparation/adhesion material is used a few minutes prior to pouring the hot applied experimental sealing compound over the prepared surface. The new material is sensitive to overheating, and optimum application techniques are still to be determined.

Best results with routing and sealing operations are attained in warm dry weather conditions. (Refer to Figure 12).

5.3.2/ Shoulder Sealing

There are a number of available methods by which shoulder sealing may be accomplished, certainly the cheapest and easiest to undertake are priming or surface treating operations.

Both of these methods have been tried by this Ministry as methods of waterproofing and reducing the amount of shoulder maintenance effort otherwise required on an unbound shoulder.

Of these methods, priming is initially the least costly, followed by single and double surface treatments. Information available on long term performance for surface treatments would indicate that a follow-up application may be required in five to eight years depending upon the quality of shoulder structure (Figure 13).

Experience to date would indicate that these types of treatment are very effective in sealing the shoulder area from the ingress of water and have successfully maintained pavement edge integrity.

Edge cracking with concrete pavements is, however, a common occurrance when shoulder treatment is used because of its more rigid nature and inability to conform in the same manner as a flexible pavement to temperature shrinkage and to vertical movement. The pavement edge joint opens up in the winter to allow ingress of water. The installation of subsurface drains at the pavement edge should therefore be considered as well as joint sealing for effective protection of concrete pavements.

5.3.3/ Subdrains

Subdrains are particularly effective in removing water adjacent to the pavement structure which has entered through shoulder areas.

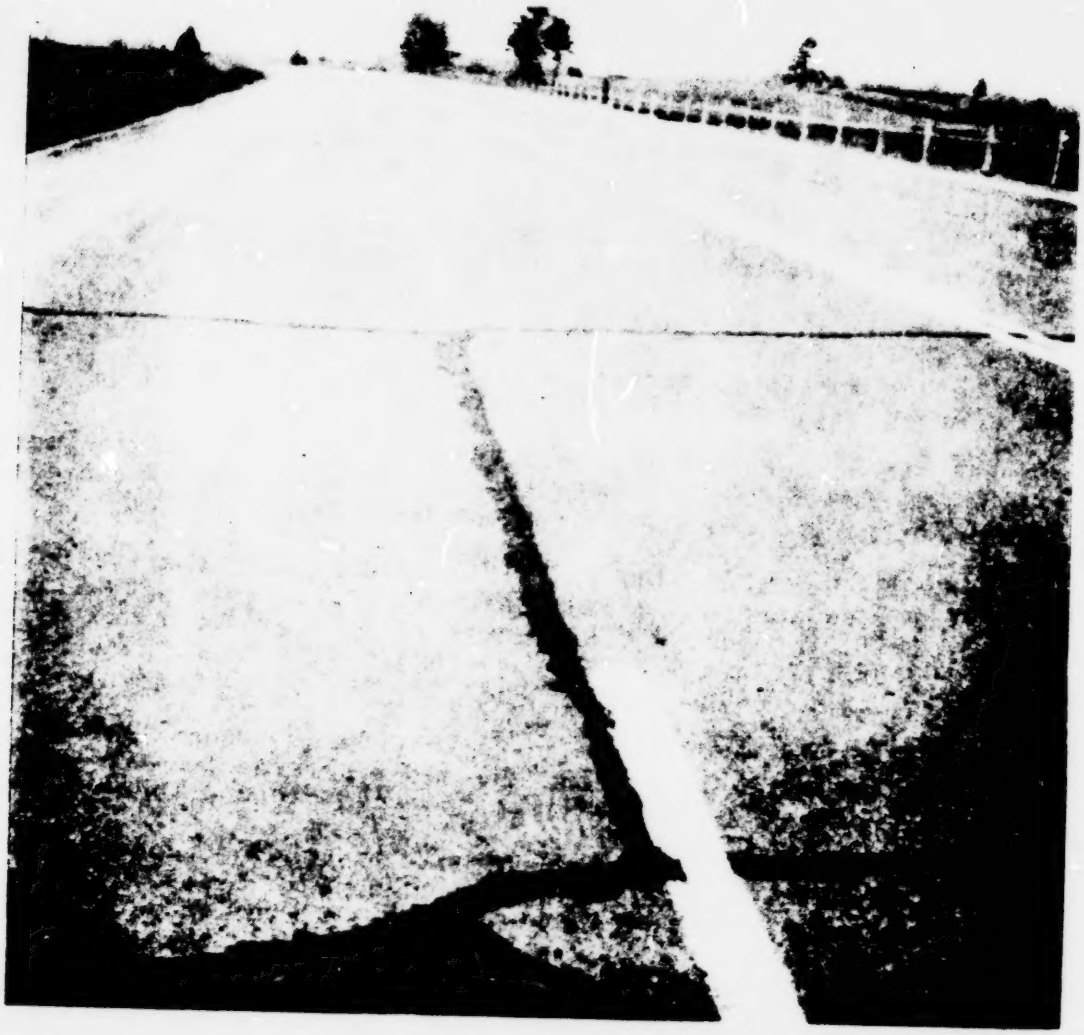


**Figure 12/ Effectively Routed and Sealed Crack**

**Figure 13/ Shoulder Sealing with a Single Surface Treatment has Successfuly Sealed the Shoulder Area Preventing Excessive Pavement Edge Curl**

Many hundreds of miles of four inch diameter slotted plastic subdrain pipe wrapped with filter cloth have been ploughed in along the pavement edges of our concrete pavements. Installation depth is normally at the bottom of the underlying subbase or granular material (Figure 14).

**Figure 14/ Installation of Subdrains Along Hwy 401. A Concrete Pavement Beginning to Exhibit 'Stepping'**

Outlet drains are usually specified at 500 foot intervals for this type of installation (Figure 15). Specific areas of application may necessitate deeper installation depths with lateral drainage under the road structure itself (Figure 16).

**Figure 15/ Outlet Drains Shortly after Rainfall**

5.3.4/
Strengthening and repairing sections of roadway weakened by water ingress into the pavement structure is normally effected by hot mix patching. The extent and type of existing distress will determine the required overlay depth.

It is particularly important, however, that the cause and not the result of the problem be addressed at the same time. Drainage improvement either internal (subdrains) or external (improved ditching) will in all likelihood be required as well.

## 6/ DEVELOPING A PROGRAM FOR PREVENTIVE MAINTENANCE

To implement the concepts of preventive maintenance, a program or plan is needed to address preventive maintenance activities on a regular basis and in a systematic manner.

Within any given highway system there are highways of varying age and construction types, subject to extremes in terms of traffic volumes and affected to varying degrees by a broad spectrum of so called 'aging' deficiencies.

**Figure 16/ Specific Subdrain Installation Area. Note Amount of Free Water that has Entered Excavated Trench from Underlying Subbase. Severe Frost Heaving had Previously Occurred at this Location**

Ideally the optimum time to address preventive maintenance needs of a highway is before water related deficiencies occur to the extent that the pavement performance and life expectancy are adversely affected. For new pavements this means addressing actual needs on an ongoing basis and commencing this type of work as early as possible in the life of the pavement and continuing until further efforts of this type are no longer warranted from a cost return point of view.

There will however, be many roads within the system that have been affected and degraded by water induced structural damage over a period of many years. These sections of road should be addressed for suitability to the preventive maintenance program, and a 'catch up' program may be required initially coincident with a planned 'ongoing' program.

All roads may not benefit much by this type of treatment approach because they may have deteriorated beyond the point where it is economically justified, or because rehabilitation is quite close.

Treatment types may also vary from road to road dependent both upon the type of exhibited distress and the particular road structure under consideration.

## 6.1/ Procedural Steps

### 6.1.1/ Initial Risk Determinations

Performance and deficiency information is required on all roads within the given system considered for preventive maintenance treatment.

Existing and future needs of each section of road are determined by a site assessment of performance, existing distresses and their anticipated relation to future performance.

Initial risk determinations are made by comparing the current age/present condition status of each candidate section of road with average performance curves compiled from existing performance data.

Those sections of road presently performing 'better than average' may initially be asessed or assumed to be stronger than normal and therefore constitute lower risk candidates.

Those sections of road presently performing 'below average' may conversely be considered higher risk candidates and indeed many sections of road may at this initial stage be assigned to a low priority category or eliminated for treatment because of past or anticipated poor future performance (Figure 8).

### 6.1.2/ Assessment of Needs and Costs

Types of remedial work requirements (now and future) and their present worth costs must be determined for each section or road considered. These activities would normally constitute one of the following for reasons previously explained:

a) crack sealing
b) drainage improvement
c) shoulder sealing operations
d) localized strengthening

### 6.1.3/ Effects of Proposed Remedial Work

For each section of road considered for treatment it is necessary to make some initial estimate or 'best guess' of the effect of the treatment on the extension of road serviceability at an acceptable performance level, so that the benefits of doing such work may be ascertained. These 'benefits' would be assigned a dollar value by discounting the normally planned rehabilitation costs at a predetermined discount rate over the estimated extended life period to arrive at a present worth of deferred costs. These savings may

then be compared to the present worth costs of doing the preventive maintenance work. This may be expressed as a benefit/cost ratio for each section of highway considered.

6.2/ Prioritizing Needs

A priority listing of preventive maintenance needs may be determined by comparing individual benefit/cost ratios for each section of highway considered for treatment. Normally 'lower' risk candidates would be prioritized ahead of 'higher' risk candidates where benefit/cost ratios are comparable. Higher priority should be also given to these sections of road with higher traffic volumes where risk and benefit/cost ratios are comparable.

## 7/ AN EXAMPLE OF A DEVELOPED PREVENTIVE MAINTENANCE PROGRAM

### 7.1/ Procedure Steps

1. List candidate roads determined by utilizing pavement condition rating criteria.

2. Determine treatment requirements for 1980 and costs.

3. Determine if further treatment will be required over the lifespan of the road and what the present worth costs are. This can be done by estimating uninflated future worth costs and discounting at the appropriate discount rate over the determined time frame to determine what the total preventive maintenance costs are (present worth).

4. Estimate or list if presently known the advanced program year for each road section.

5. Estimate the most probably (best guess) life extension of each section of road under consideration.

6. Discount each established program value at the appropriate discount rate from its present program year to 1980 and from its extended program year to 1980. The difference between them is the deferred savings (present worth).

7. Calculate the benefit/cost ratio by dividing the deferred saving by the total preventive maintenance cost (present worth).

8. Indicate the risk as being 'higher' or 'lower' based upon preselection criteria.

9. Select and prioritize those candidates whose benefit/cost ratios exceed 5 (this will be adjusted as we become 'more' confident in our predictions). Further prioritize by considering risk and traffic volumes for selected candidates with comparable benefit/cost ratios.

Table 1 shows an example of a partial program listing.

**Table 1/ An Example of a Partial Program Listing**

| Section | Hwy. No. | Location | Recommended Treatment 1980 | Further Treatment Required Yes/No | Further Treatment Type | 1980 Preventive Maintenance Cost $ | Total Preventive Maintenance Cost (Present Worth) ① | Existing PCR | Program Year (Actual or Estimated) | Program Value (Uninflated Future worth) | Pavement Life Ext. Years (Estimated) | Deferred Savings $ ② | B/C ratio ②/① | Risk H, M, L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 417 | Ramsay Creek to Quebec Boundary | Rout and seal cracks & sub drains | Yes | Some | 30,000 | 36,499 | 85 | 1985 | 5,500,000. | 5 | 1,251,360 | 34 | Lower |
| 2 | 31 | Morrisburg to Winchester Springs | Rout and seal | Yes | Some | 1,000 | 5,000 | 95 | 1994 | 400,000 | 5 | 41,904 | 8 | Lower |
| 3 | 417 | Blair Road to Montreal road | Rout and seal cracks Sub drain installation repair spalls | No | None | 25,000 | 25,000 | 60 | 1980 1981 | 285,000 | 6 | 105,564 | 4 | Higher |

## Example of Benefit/Cost Calculations

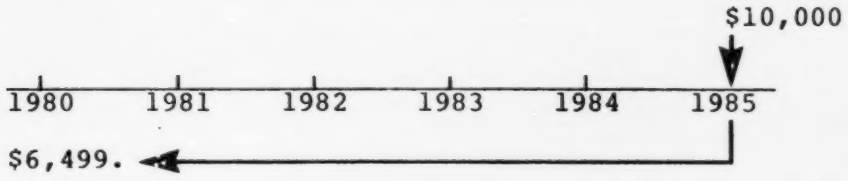
(Refer to Section 1 on Partial Program Listing)

Assume 9% discount 0% inflation for this example

1. Location - Hwy. 417, Ramsay Creek to Quebec Border

2. Routing and sealing recommended for 1980 at a cost of $30,000.

3. Additional routing and sealing plus sub drain installation recommended for 1985 at an uninflated future worth of $10,000.

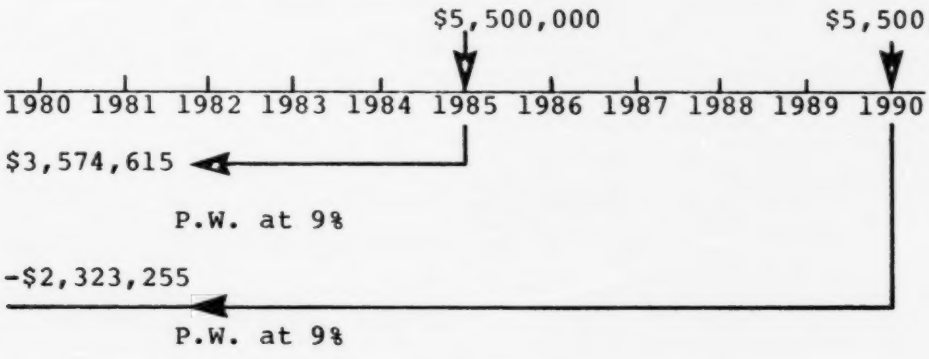



Total Preventive Maintenance Costs (Present Worth) are then $30,000. + $6,499. = $36,499.

4. Advance program year is 1985.

5. Best determination as to probable life extension is 5 years, which would advance program year to 1990.

6.




$1,251,360

Deferred Costs = Benefits

## 8/ IMPLEMENTING A PREVENTIVE MAINTENANCE PROGRAM

It is important to realize that the key to formulating and implementating a successful preventive maintenance program depends upon the proper identification and prioritization of road needs requirements so that the objectives of extended life are actually realized. This does not imply an upgrading of existing maintenance quality standards, which in many cases are designed to address corrective maintenance concerns. It is not the 'what and how' but the 'when and why' that form the essential ingredient of a preventive maintenance program.

Consequently, maintenance management quantity standards which in many cases have previously determined resources allocation and funding levels must be reassessed on the basis of a more comprehensive maintenance plan encompassing both corrective and preventive maintenance. Since life extension can free rehabilitation funds for other purposes, justification exists for additional funding for a preventive maintenance program. In Ontario, the preventive maintenance needs identification is currently the responsibility of the Geotechnical Section. This section has traditionally been responsible for making the pavement condition rating assessments used for determining road rehabilitation needs; it is logical to extend their responsibility to the identification of candidate sections for preventive maintenance.

## 9/ A PAVEMENT MANAGEMENT SYSTEM

### The Relationship of Preventive Maintenance to a Maintenance and Rehabilitation Management System

Maintenance management and rehabilitation management of a road system need no longer be viewed as separate and distinct delivery areas.

The determination of rehabilitation needs and priorities are truly influenced by both the amount and types of preventive maintenance work planned for and carried out as determined by the Maintenance Plan.

Preventive Maintenance forms a neccessary part of any overall strategic maintenance plan and can serve as the catalyst that welds and syncronizes the two management systems into a comprehensive Pavement Management System, as is shown in Figure 17.

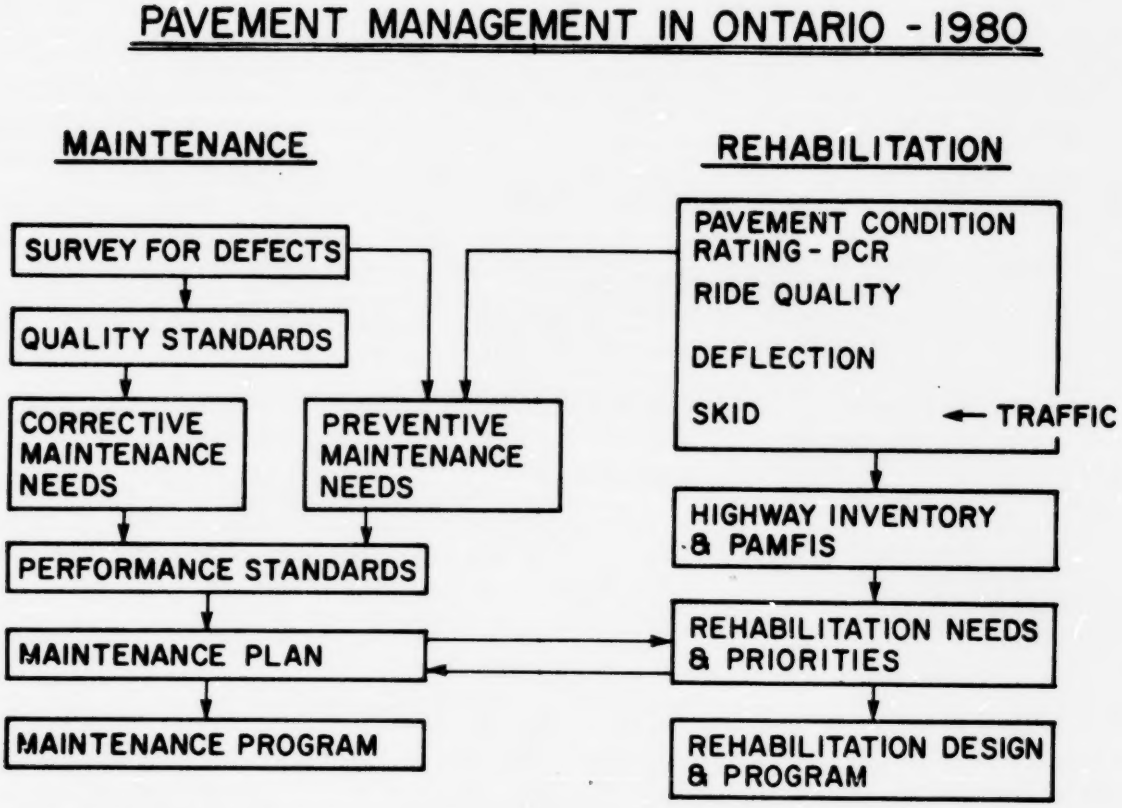



**Figure 17/ The Role of Preventative Maintenance in Pavement Management**

10/ PREVENTIVE MAINTENANCE PROGRAM

Monitoring and Evaluation

By rejecting or by assigning low priority to projects with high risk based on past performance and by further restricting candidates to some minimum value of benefit/cost ratios, preventive maintenance programs can be trimmed to a size consistent with available funds.

Certain assumptions have to be made in the program development where the element of risk or certainty of success is more difficult to ascertain in the earlier programs, such as the effectiveness of individual treatment types and the overall effect of treatment on the service life extension of the road section treated. These assumptions certainly influence the evaluations and priorities.

It is therefore, important that program monitoring and assessment be an integral part of any program implementation.

Monitoring may be initially undertaken by:

a) annually reviewing the effectiveness of treatment types used.
b) annually reviewing road performance data for indications of service life extension.

An early evaluation of results should confirm the impact this type of program is expected to have on the rehabilitation program.

Subsequent evaluation of the program will verify or fine tune estimates by noting the actual road system life extension achieved and the benefits attained.

## 11/ RECOMMENDATIONS

It is recommended that preventive maintenance:

- be recognized as an essential element of any comprehensive maintenance or pavement management system;
- be recognized for its potential to delay rehabilitation and thus free those funds for other uses;
- be recognized by establishing forthwith, 'catch up' and 'on-going' programs.

## 12/ REFERENCES

1. Godfrey, K.A., "Pavement Management Systems - Can they save pavements, cut rehab cots?" Civil Engineering - ASCE, Nov. 1979.

2. IBRD "Report", "Highway Maintenance: It Costs a lot only if it is not done", Reprinted in shortened form. International Road Federation, World Highways, Oct. 1979.

3. NCHRP, "Consequences of Deferred Maintenance", Synthesis of Highway Practice 58, Transportation Research Board, Washington, D.C., May 1979.

4. OECD Road Research, "Maintenance Techniques for Road Surfacings", Organization for Economic Co-operationg and Development, Paris, France, October 1978.

5. Chong, G., Phang, W.A., & Jewer, F., "Pavement Maintenance Guidelines: Distresses, Maintenance Alternatives and Performance Standards".

6. Cedergren, H.W., "Drainage of Highway and Airfield Pavements", John Wiley and Sons, New York, August 1974.

7. Wrong, G.A., Phang, W.A., Stott, G.M., "Roadway Drainage in Seasonal Frost Areas", Roads and Transportation Association of Canada, September 1975.

8. Wilkins, E.B., "Pavement Evaluation Studies in Canada", International Conference on the Structural Design of Asphalt Pavements", Ann Arbor, Michigan, August 1962.